

ShakeCast:

A Tool for Raising Situational Awareness in Emergency Response

Meeting of the Statewide Emergency Planning
Committee (SWEPC)

February 24, 2015

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Information

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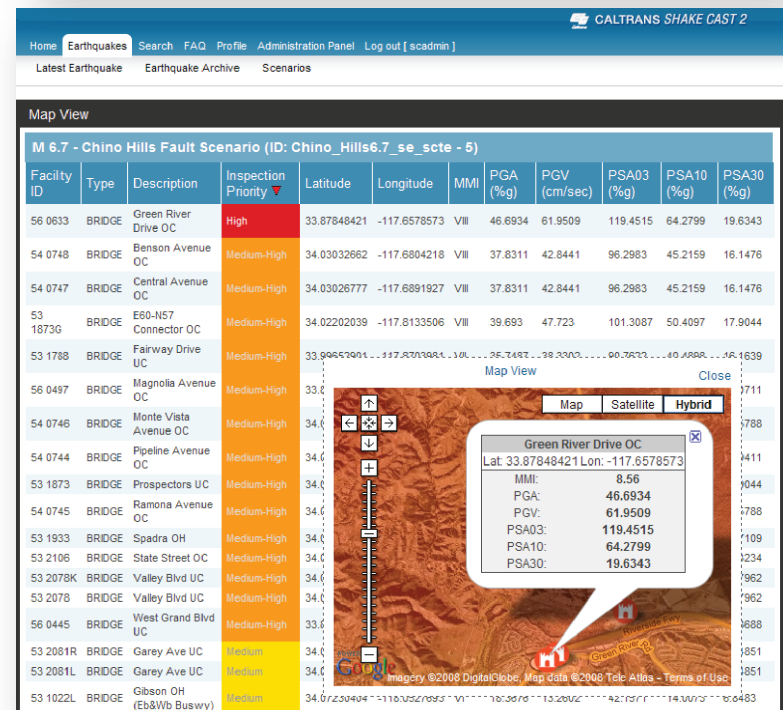
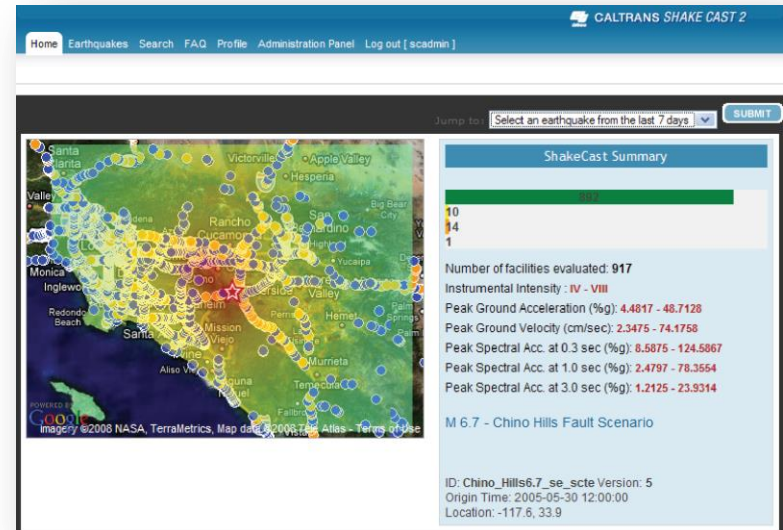


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Innovation and System Information



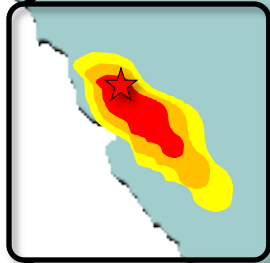
What is ShakeCast?

- Open-source web application.
- Retrieves measured shaking data within minutes after an earthquake.
- Compares spatial shaking distribution with unique bridge vulnerabilities.
- Generates hierarchical lists and maps of bridges most likely impacted.
- Sends notifications to responders within 10 minutes following the event.
- Developed by the USGS in 2003.
- Caltrans-USGS work resulted in *ShakeCast v2* in 2008, and has since been adopted by others.
- *ShakeCast v3* to be released in 2014.
- Raises situational awareness after an earthquake.
- Represents the most reliable information within the first minutes to hours following an event.



ShakeCast Analysis

Earthquake occurs,
magnitude and
epicenter identified
(1 min)



ShakeMap provides
distribution of ground
shaking (5-10 min)

ShakeCast determines
the bridges that fall in
the regions of strong
shaking.

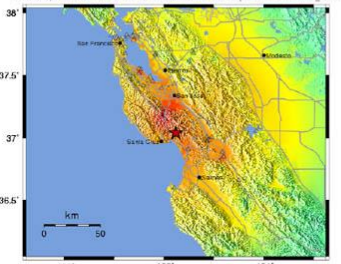
ShakeCast identifies the bridges that are *more likely* to have damage due to the critical combination of damaging shaking levels and greater vulnerability. (10 min)

Caltrans ShakeCast Server (C)
<Loren.Turner@dot.ca.gov>
Tue Oct 17, 10:09:05 PM PDT
Subject: BRIDGE ASSESSMENT: 6.9, 7 km NNE of Aptos, CA (Loma_Prieta_sce Version 1)

Caltrans ShakeCast Preliminary Earthquake Bridge Impact Report

This report supersedes any earlier reports about this event. This is a computer-generated message and has not yet been reviewed by an Engineer or Seismologist. Information about the epicenter, magnitude, location, date, and time are provided by the California Integrated Seismic Network (CISN). The analysis of potential bridge damage in this report is based upon an initial ShakeMap (unverified) and estimated fragilities for Caltrans bridges. Bridge fragility models were adopted from HAZUS and Basoz & Mander (1999). This report is intended to be used as a first response tool to assist in identifying Caltrans bridges most likely impacted by the event.

CISN ShakeMap for Loma Prieta Earthquake
Tue Oct 17, 10:09:05 PM PDT, M=6.9, 7.0 km NNE of Aptos, CA (Loma_Prieta_sce Version 1)



Station	Lat	Lon	Mag	Dist	Intensity	Station	Lat	Lon	Mag	Dist	Intensity
01	37.00	-122.10	6.9	7.0	0.5	02	37.00	-122.10	6.9	7.0	0.5
03	37.00	-122.10	6.9	7.0	0.5	04	37.00	-122.10	6.9	7.0	0.5
05	37.00	-122.10	6.9	7.0	0.5	06	37.00	-122.10	6.9	7.0	0.5
07	37.00	-122.10	6.9	7.0	0.5	08	37.00	-122.10	6.9	7.0	0.5
09	37.00	-122.10	6.9	7.0	0.5	10	37.00	-122.10	6.9	7.0	0.5
11	37.00	-122.10	6.9	7.0	0.5	12	37.00	-122.10	6.9	7.0	0.5
13	37.00	-122.10	6.9	7.0	0.5	14	37.00	-122.10	6.9	7.0	0.5
15	37.00	-122.10	6.9	7.0	0.5	16	37.00	-122.10	6.9	7.0	0.5
17	37.00	-122.10	6.9	7.0	0.5	18	37.00	-122.10	6.9	7.0	0.5
19	37.00	-122.10	6.9	7.0	0.5	20	37.00	-122.10	6.9	7.0	0.5
21	37.00	-122.10	6.9	7.0	0.5	22	37.00	-122.10	6.9	7.0	0.5
23	37.00	-122.10	6.9	7.0	0.5	24	37.00	-122.10	6.9	7.0	0.5
25	37.00	-122.10	6.9	7.0	0.5	26	37.00	-122.10	6.9	7.0	0.5
27	37.00	-122.10	6.9	7.0	0.5	28	37.00	-122.10	6.9	7.0	0.5
29	37.00	-122.10	6.9	7.0	0.5	30	37.00	-122.10	6.9	7.0	0.5
31	37.00	-122.10	6.9	7.0	0.5	32	37.00	-122.10	6.9	7.0	0.5
33	37.00	-122.10	6.9	7.0	0.5	34	37.00	-122.10	6.9	7.0	0.5
35	37.00	-122.10	6.9	7.0	0.5	36	37.00	-122.10	6.9	7.0	0.5
37	37.00	-122.10	6.9	7.0	0.5	38	37.00	-122.10	6.9	7.0	0.5
39	37.00	-122.10	6.9	7.0	0.5	40	37.00	-122.10	6.9	7.0	0.5
41	37.00	-122.10	6.9	7.0	0.5	42	37.00	-122.10	6.9	7.0	0.5
43	37.00	-122.10	6.9	7.0	0.5	44	37.00	-122.10	6.9	7.0	0.5
45	37.00	-122.10	6.9	7.0	0.5	46	37.00	-122.10	6.9	7.0	0.5
47	37.00	-122.10	6.9	7.0	0.5	48	37.00	-122.10	6.9	7.0	0.5
49	37.00	-122.10	6.9	7.0	0.5	50	37.00	-122.10	6.9	7.0	0.5
51	37.00	-122.10	6.9	7.0	0.5	52	37.00	-122.10	6.9	7.0	0.5
53	37.00	-122.10	6.9	7.0	0.5	54	37.00	-122.10	6.9	7.0	0.5
55	37.00	-122.10	6.9	7.0	0.5	56	37.00	-122.10	6.9	7.0	0.5
57	37.00	-122.10	6.9	7.0	0.5	58	37.00	-122.10	6.9	7.0	0.5
59	37.00	-122.10	6.9	7.0	0.5	60	37.00	-122.10	6.9	7.0	0.5
61	37.00	-122.10	6.9	7.0	0.5	62	37.00	-122.10	6.9	7.0	0.5
63	37.00	-122.10	6.9	7.0	0.5	64	37.00	-122.10	6.9	7.0	0.5
65	37.00	-122.10	6.9	7.0	0.5	66	37.00	-122.10	6.9	7.0	0.5
67	37.00	-122.10	6.9	7.0	0.5	68	37.00	-122.10	6.9	7.0	0.5
69	37.00	-122.10	6.9	7.0	0.5	70	37.00	-122.10	6.9	7.0	0.5
71	37.00	-122.10	6.9	7.0	0.5	72	37.00	-122.10	6.9	7.0	0.5
73	37.00	-122.10	6.9	7.0	0.5	74	37.00	-122.10	6.9	7.0	0.5
75	37.00	-122.10	6.9	7.0	0.5	76	37.00	-122.10	6.9	7.0	0.5
77	37.00	-122.10	6.9	7.0	0.5	78	37.00	-122.10	6.9	7.0	0.5
79	37.00	-122.10	6.9	7.0	0.5	80	37.00	-122.10	6.9	7.0	0.5
81	37.00	-122.10	6.9	7.0	0.5	82	37.00	-122.10	6.9	7.0	0.5
83	37.00	-122.10	6.9	7.0	0.5	84	37.00	-122.10	6.9	7.0	0.5
85	37.00	-122.10	6.9	7.0	0.5	86	37.00	-122.10	6.9	7.0	0.5
87	37.00	-122.10	6.9	7.0	0.5	88	37.00	-122.10	6.9	7.0	0.5
89	37.00	-122.10	6.9	7.0	0.5	90	37.00	-122.10	6.9	7.0	0.5
91	37.00	-122.10	6.9	7.0	0.5	92	37.00	-122.10	6.9	7.0	0.5
93	37.00	-122.10	6.9	7.0	0.5	94	37.00	-122.10	6.9	7.0	0.5
95	37.00	-122.10	6.9	7.0	0.5	96	37.00	-122.10	6.9	7.0	0.5
97	37.00	-122.10	6.9	7.0	0.5	98	37.00	-122.10	6.9	7.0	0.5
99	37.00	-122.10	6.9	7.0	0.5	100	37.00	-122.10	6.9	7.0	0.5

Event Summary

Name: (Unnamed Event), Version 1

Magnitude: 6.9
ID: Loma_Prieta_sce-1
Location: 7 km NNE of Aptos, CA
Latitude: 37.04
Longitude: -122.86
Time: 1999-10-18 00:04:00 GMT

Bridge Assessment Summary

Maximum Peak 1.0 sec Spectral Acceleration: 105.3903g
Maximum Acceleration: (not measured)
Total number of bridges assessed: 2030
Summary by inspection priority:
High 22 High Priority for full engineering assessment
Medium-High 107 Medium-High Priority for full engineering assessment
Medium 106 Medium Priority for full engineering assessment
Low 1795 Low Priority for full engineering assessment; quick visual inspection likely sufficient.

Bridge Assessment Details

Bridges presented in the table below are sorted in order of severity of impact to bridges.

Bridge Name	Bridge Number	Dist-City-Rte-PM	Inspection Priority	1sec Peak Spectral Acceleration (%)	Exceedance Ratio
Ralston Avenue OC	35 0114	04-SM-101-9.55-BMT	High	105.3903	2.934
Via Del Oro OH	37 0477L	04-SCL-085-1.22-SJS	High	49.2711	2.472
San Mateo-Hayward Bridge	35 0054	04-SM-092-R14.44-FSTC	High	49.6514	2.167
Constitution Way OC	33 0513K	04-ALA-260-R.86-ALA	High	68.2755	1.415
Meridian Road Underpass	37 0258	04-SCL-280-R3.89-SJS	High	59.9229	1.122
Campbell Underpass	37 0135	04-SCL-017-12.22-CMB	High	70.2112	1.087
East Hillsdale Blvd OC	35 0138	04-SM-101-11.15-SM	High	68.3762	1.071
Redwood Creek	35 0145	04-SM-101-6.2-RDWC	High	61.0924	1.064
Sfobb-Approach Lower Deck	34 0118R	04-SF-080-4.95-SF	High	33.2578	1.057
Holly Street OC	35 0037	04-SM-101-8.4	High	65.904	1.048
Route 13/80 Separation (North)	33 0191G	04-ALA-013-13.92-BER	High	66.6766	1.046
Race Street Overcrossing	37 0260	04-SCL-280-R3.76-SJS	High	59.9229	1.045
Presidio Viaduct	34 0019	04-SF-101-9.14-SF	High	68.3123	1.035
South Delaware Street UC	35 0158L	04-SM-092-R11.61-SM	High	35.1822	1.030
South Delaware Street UC	35 0158R	04-SM-092-R11.61-SM	High	35.1822	1.030
Powell Street UC	33 0020	04-ALA-080-3.79-EMV	High	66.6766	1.020
Redwood Harbor Overhead	35 0065	04-SM-101-5.5-RDWC	High	56.8606	1.018
Macarthur Avenue OC	37 0100	04-SCL-280-L5.18-SJS	High	54.4613	1.012
N101-S84 Connector OC	35 0081G	04-SM-101-5.39-RDWC	High	56.8606	1.009
N17-N85 Connector Separation	37 0515G	04-SCL-017-9.24-LGTS	High	86.2137	1.008
San Francisco Creek	35 0013	04-SM-101-01	High	55.3678	1.007
N8587-S280 Connector Separation	37 0396H	04-SCL-087-5.1-SJS	High	50.5564	1.001
Blossom Hill Road OC	37 0345	04-SCL-082-R.35-SJS	Medium-High	49.4998	0.951
Harkins Slough Road OC	36 0089	05-SCR-001-R2.27-WAT	Medium-High	56.0768	0.938
Sunol Street Rr UC	37 0263L	04-SCL-280-R3.41-SJS	Medium-High	52.8878	0.909
Sunol Street Rr UC	37 0263R	04-SCL-280-R3.41-SJS	Medium-High	52.8878	0.909
Winchester Boulevard OC	37 0195	04-SCL-280-4.57-SJS	Medium-High	55.327	0.898
Lincoln Avenue UC	37 0262L	04-SCL-280-R3.51-SJS	Medium-High	52.8878	0.896
South Gilroy OH	37 0305L	04-SCL-101-R5.1	Medium-High	43.2728	0.896

Bridge Assessment Summary

Maximum Peak 1.0 sec Spectral Acceleration: 188.76%g

Maximum Acceleration: (not measured)

Total number of bridges assessed: 3133

Summary by inspection priority:

High	119	High Priority for full engineering assessment
Medium-High	156	Medium-High Priority for full engineering assessment
Medium	152	Medium Priority for full engineering assessment
Low	2706	Low Priority for full engineering assessment; quick visual inspection likely sufficient.

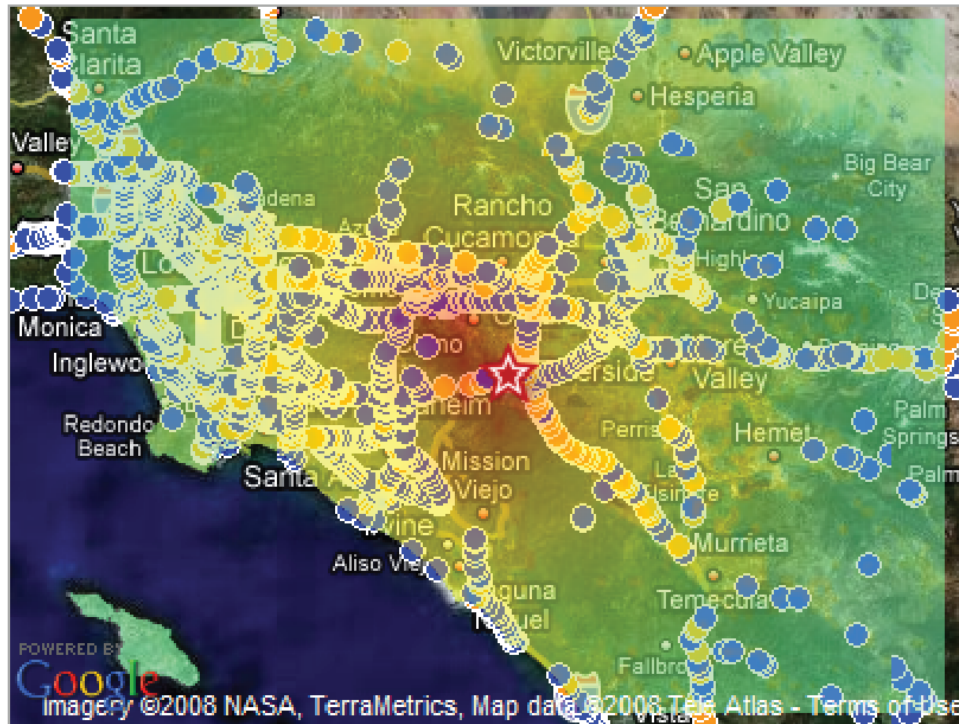
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Redwood Harbor Overhead	35 0065	04-SM-101-5.5-RDWC	High	56.8606	1.018
Macarthur Avenue OC	37 0100	04-SCL-280-L5.18-SJS	High	54.4613	1.012
N101-S84 Connector OC	35 0081G	04-SM-101-5.39-RDWC	High	56.8606	1.009
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Harkins Slough Road OC	36 0089	05-SCR-001-R2.27-WAT	Medium-High	56.0768	0.938
Sunol Street Rr UC	37 0263L	04-SCL-280-R3.41-SJS	Medium-High	52.8878	0.909
Sunol Street Rr UC	37 0263R	04-SCL-280-R3.41-SJS	Medium-High	52.8878	0.909
Winchester Boulevard OC	37 0195	04-SCL-280-4.57-SJS	Medium-High	55.327	0.898
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South Gilroy OH	37 0305L	04-SCL-101-R5.1	Medium-High	43.2728	0.896

Jump to:

SUBMIT



ShakeCast Summary

892

10
14
1

Number of facilities evaluated: **917**

Instrumental Intensity : **IV - VIII**

Peak Ground Acceleration (%g): **4.4817 - 48.7128**

Peak Ground Velocity (cm/sec): **2.3475 - 74.1758**

Peak Spectral Acc. at 0.3 sec (%g): **8.5875 - 124.5867**

Peak Spectral Acc. at 1.0 sec (%g): **2.4797 - 78.3554**

Peak Spectral Acc. at 3.0 sec (%g): **1.2125 - 23.9314**

M 6.7 - Chino Hills Fault Scenario

ID: Chino_Hills6.7_se_scte Version: 5

Origin Time: 2005-05-30 12:00:00

Location: -117.6, 33.9

Responders can use the link in the email to go to the ShakeCast website for additional information.

M 6.7 - Chino Hills Fault Scenario (ID: Chino_Hills6.7_se_scte - 5)

Facility ID	Type	Description	Inspection Priority ▼	Latitude	Longitude	MMI	PGA (%)	PGV (cm/sec)	PSA03 (%)	PSA10 (%)	PSA30 (%)
56 0633	BRIDGE	Green River Drive OC	High	33.87848421	-117.6578573	VIII	46.6934	61.9509	119.4515	64.2799	19.6343
54 0748	BRIDGE	Benson Avenue OC	Medium-High	34.03032662	-117.6804218	VIII	37.8311	42.8441	96.2983	45.2159	16.1476
54 0747	BRIDGE	Central Avenue OC	Medium-High	34.03026777	-117.6891927	VIII	37.8311	42.8441	96.2983	45.2159	16.1476
53 1873G	BRIDGE	E60-N57 Connector OC	Medium-High	34.02202039	-117.8133506	VIII	39.693	47.723	101.3087	50.4097	17.9044
53 1788	BRIDGE	Fairway Drive UC	Medium-High	33.90552901	-117.87013981	VIII	35.7487	38.3302	90.7622	40.4888	16.1639
56 0497	BRIDGE	Magnolia Avenue OC	Medium-High	33.87848421	-117.6578573	VIII	46.6934	61.9509	119.4515	64.2799	19.6343
54 0746	BRIDGE	Monte Vista Avenue OC	Medium-High	34.03032662	-117.6804218	VIII	37.8311	42.8441	96.2983	45.2159	16.1476
54 0744	BRIDGE	Pipeline Avenue OC	Medium-High	34.03026777	-117.6891927	VIII	37.8311	42.8441	96.2983	45.2159	16.1476
53 1873	BRIDGE	Prospectors UC	Medium-High	34.02202039	-117.8133506	VIII	39.693	47.723	101.3087	50.4097	17.9044
54 0745	BRIDGE	Ramona Avenue OC	Medium-High	34.03032662	-117.6804218	VIII	37.8311	42.8441	96.2983	45.2159	16.1476
53 1933	BRIDGE	Spadra OH	Medium-High	34.02202039	-117.8133506	VIII	39.693	47.723	101.3087	50.4097	17.9044
53 2106	BRIDGE	State Street OC	Medium-High	34.03032662	-117.6804218	VIII	37.8311	42.8441	96.2983	45.2159	16.1476
53 2078K	BRIDGE	Valley Blvd UC	Medium-High	34.03032662	-117.6804218	VIII	37.8311	42.8441	96.2983	45.2159	16.1476
53 2078	BRIDGE	Valley Blvd UC	Medium-High	34.03032662	-117.6804218	VIII	37.8311	42.8441	96.2983	45.2159	16.1476

Map View Close

Map Satellite Hybrid

Green River Drive OC [X]

Lat: 33.87848421 Lon: -117.6578573

MMI: 8.56

PGA: 46.6934

PGV: 61.9509

PSA03: 119.4515

PSA10: 64.2799

PSA30: 19.6343

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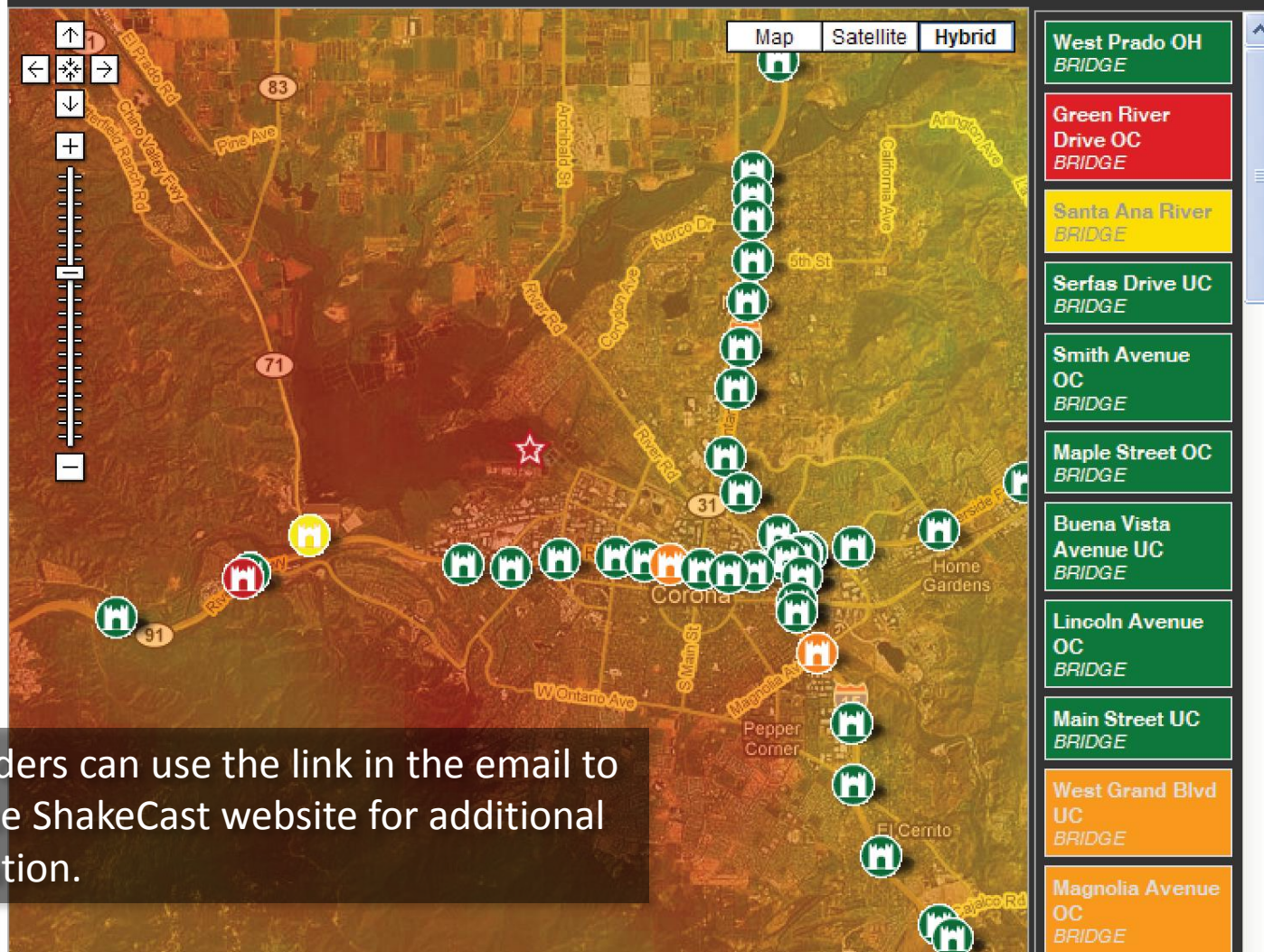
Google Maps offers different ways to view geospatial data using maps, tables, or a combination of both.

The website offers different ways to view the bridge data using maps, tables, or a combination of both.

Table View

Google Maps for ShakeMap Chino_Hills6.7_se_scte

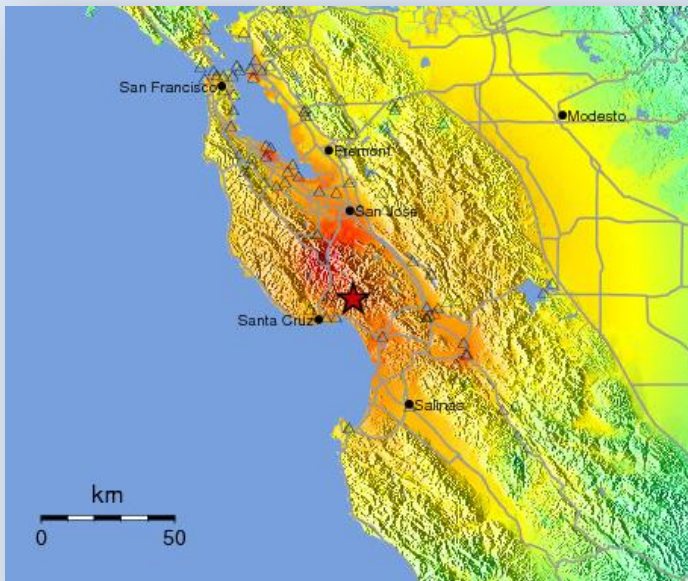
Facility Type: All  BRIDGE



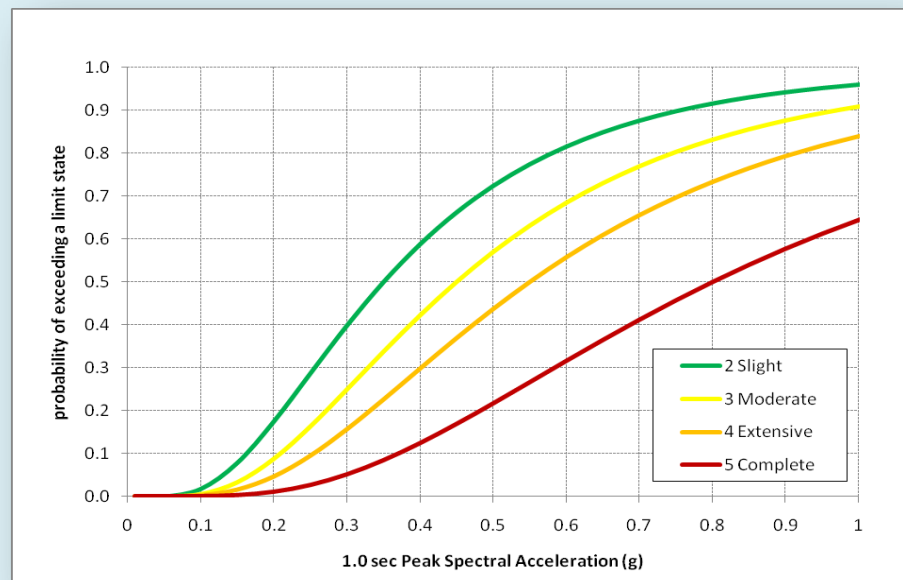
Responders can use the link in the email to go to the ShakeCast website for additional information.

Basis for ShakeCast Analysis

At each bridge location, ShakeCast analyzes the measured/interpolated ground motion against a pre-determined bridge fragility model.



Earthquake shaking forces exerted on bridges are determined from USGS *ShakeMap*.



Probabilities of damage relative to varying levels of shaking (or “fragility”) can be determined in advance for each bridge.

ShakeMap

Statewide, an array of over 1900 seismic sensors are operated by the California Integrated Seismic Network (CISN). Earthquake products and data are distributed online through the United States Geological Survey (USGS).



CGS



USGS



Caltech



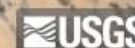
OES



UC
Berkeley



Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO



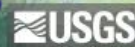
Google earth

Why use ShakeMap?

...because magnitude and epicenter alone aren't enough to determine the area of strong ground shaking.

ShakeMap provides the best estimate of the distribution of ground shaking using the CISN sensor network.

Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Data LDEO-Columbia, NSF, NOAA
Data USGS



Google earth

Imagery Date: 4/9/2013 34°03'04.63" N 117°25'48.18" W elev 1151 ft eye alt 207.68 mi

Why use ShakeCast?

DATE PALM DRIVE OC

Owner:	State
Bridge No:	56 0560
Location:	08-RIV-010-39.49
Description:	4-span; Concrete continuous; Box Beam or Girders - Multiple; 34 deg skew; 31.1 m Max Span Length; NBI Class 205; Built 1966; Improved 1966

Medium-High Priority for Inspection



INDIAN CANYON DRIVE OC

Owner:	State
Bridge No:	56 0843
Location:	08-RIV-010-33.13
Description:	3-span; Prestressed concrete; Tee Beam; 10 deg skew; 34.2 m Max Span Length; NBI Class 504; Built 2012; Improved 2012

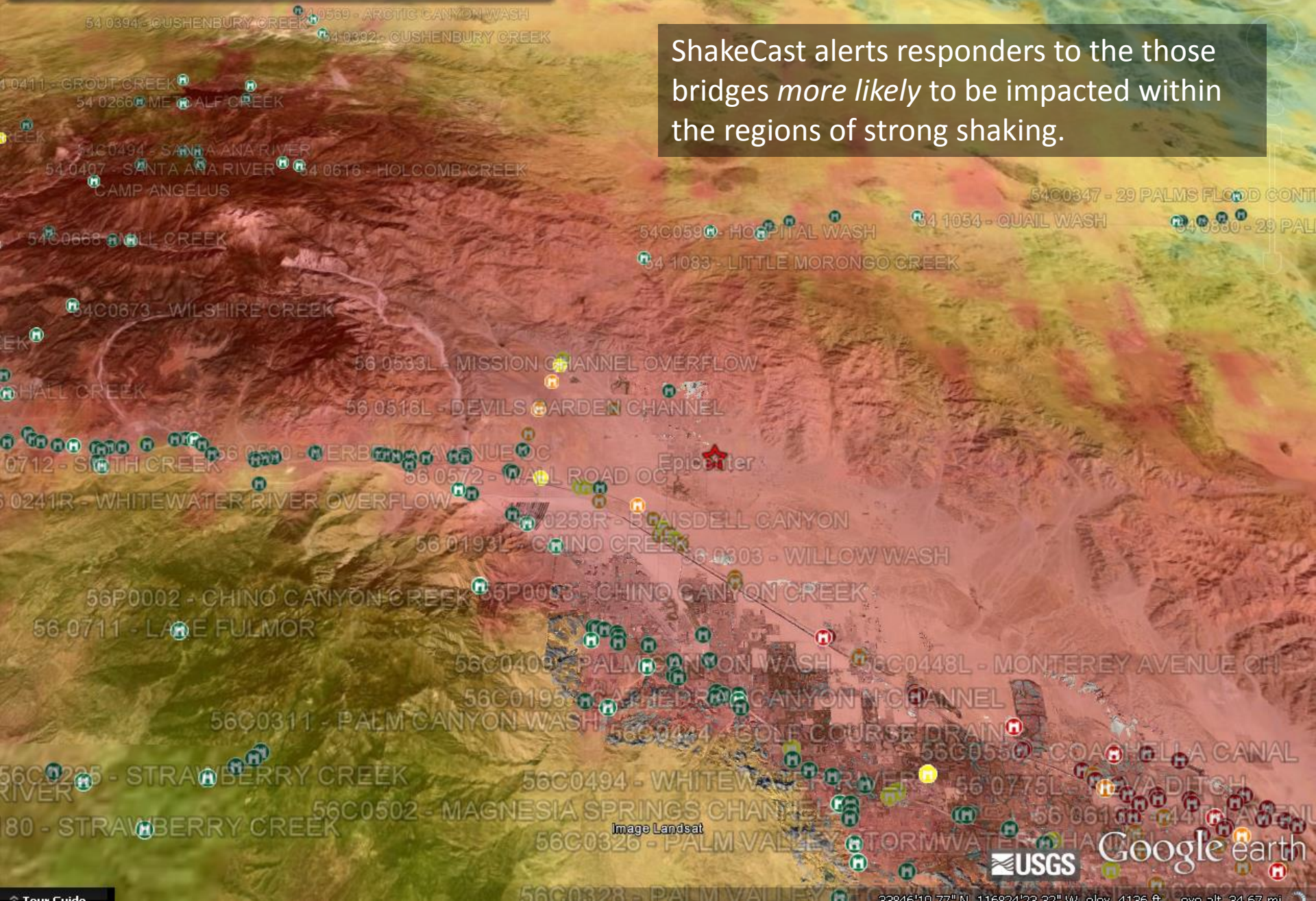
Low Priority for Inspection



Bridges that may appear similar can have very different performance characteristics under the same ground shaking conditions.

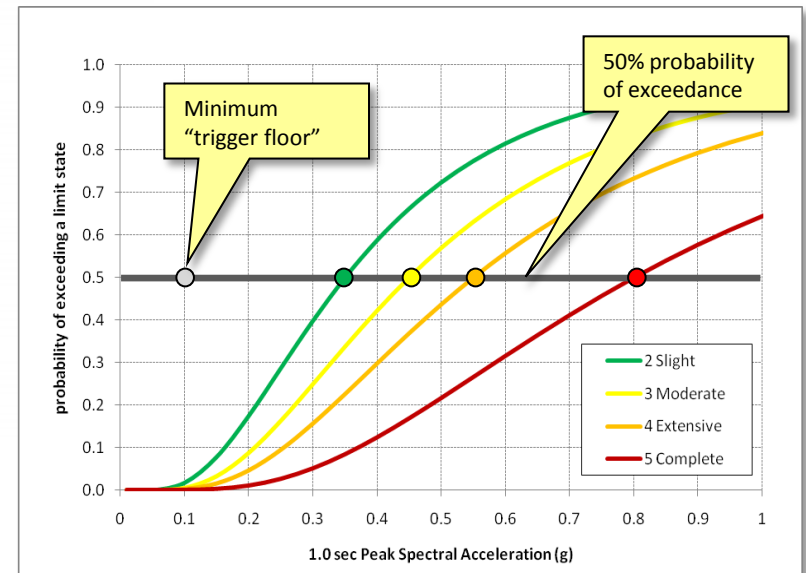
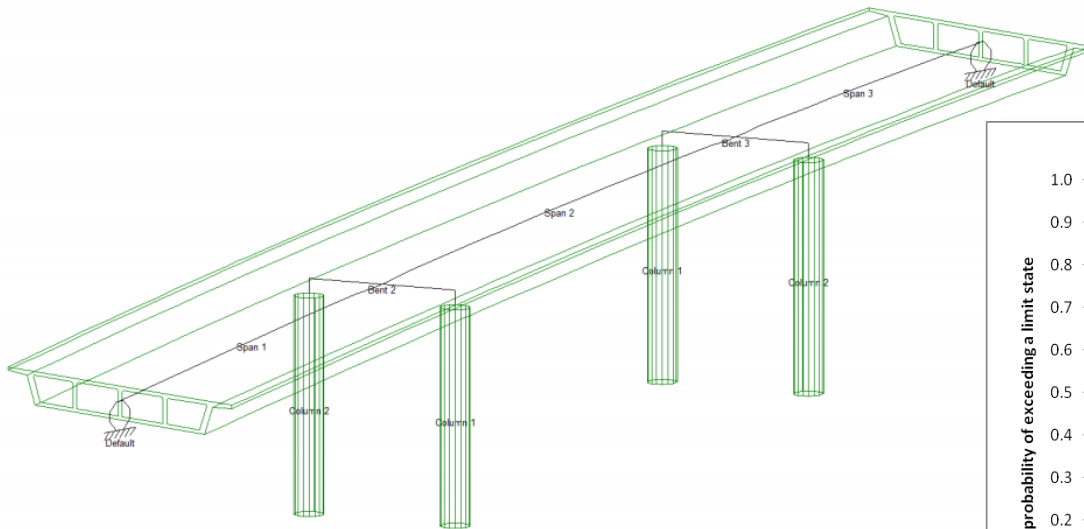
Why use ShakeCast?

ShakeCast alerts responders to the those bridges *more likely* to be impacted within the regions of strong shaking.



Bridge Fragility Modeling

- We observe that some types of bridges perform better than others for a given ground motion. Examples:
 - Post-1991 designs perform better than pre-1971
 - Short, single-span bridges have performed well in past earthquakes
 - Bridges with no skew perform better than those with higher skew
- A *fragility model* captures these differences in a probabilistic framework.



Caltrans-ShakeCast Usage

- The Department has hundreds of current subscribers to ShakeCast notifications all levels throughout the organization.
 - District Maintenance and Construction staff
 - Traffic Management Centers (TMC)
 - District and Headquarters Emergency Operation Centers (EOC)
 - Structure Maintenance & Investigations
 - Executive Management
 - Public Affairs
- The use of ShakeCast notifications has been integrated into formal Caltrans response protocols.

Others Using ShakeCast



IAEA



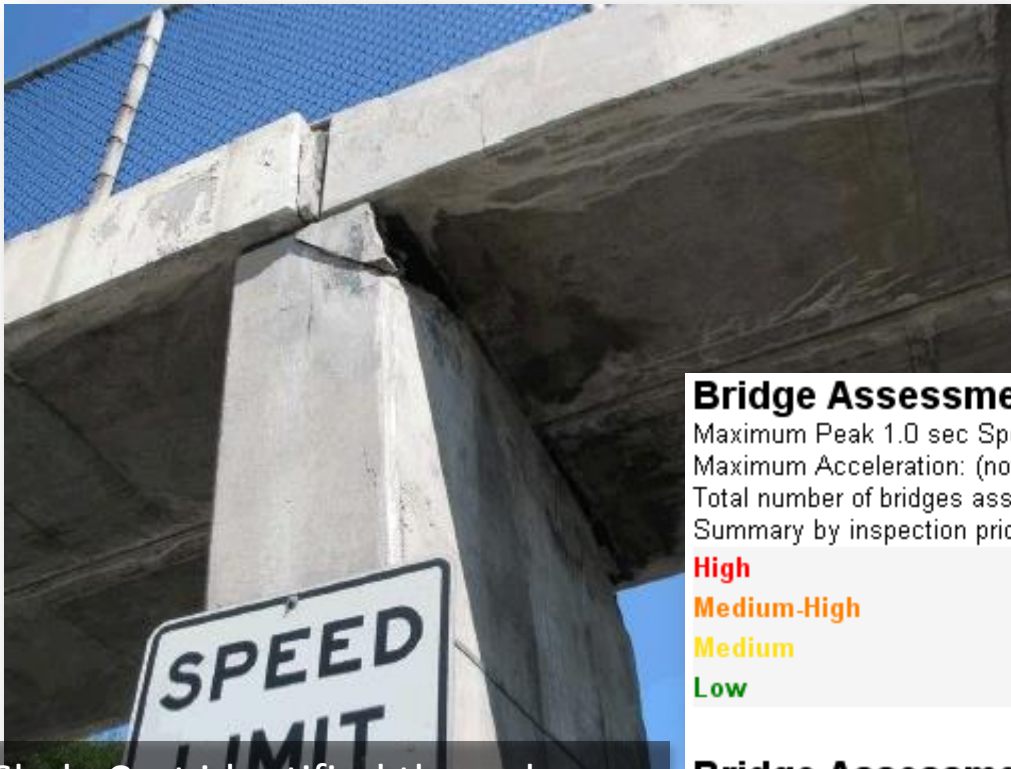
Degenkolb



Walmart

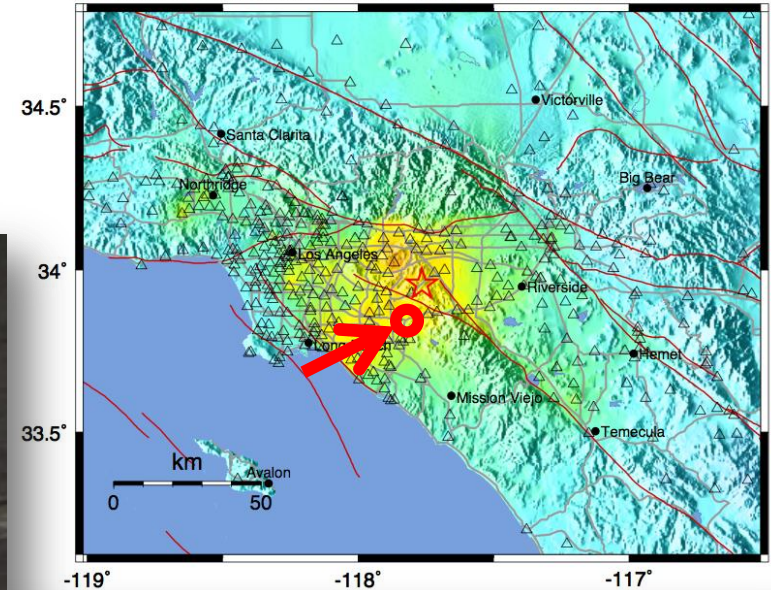


5.4 Chino Hills July 2008



ShakeCast identified the only bridge damaged in this event as the 3rd highest priority for inspection.

CISN ShakeMap : 4.0 mi SE of Diamond Bar, CA
Tue Jul 29, 2008 11:42:15 AM PDT M 5.4 N33.96 W117.76 Depth: 13.7km ID:14383980



Bridge Assessment Summary

Maximum Peak 1.0 sec Spectral Acceleration: 34.7183%g

Maximum Acceleration: (not measured)

Total number of bridges assessed: **468**

Summary by inspection priority:

High	[NULL]	High Priority for full engineering assessment
Medium-High	[NULL]	Medium-High Priority for full engineering assessment
Medium	[NULL]	Medium Priority for full engineering assessment
Low	468	Low Priority for full engineering assessment

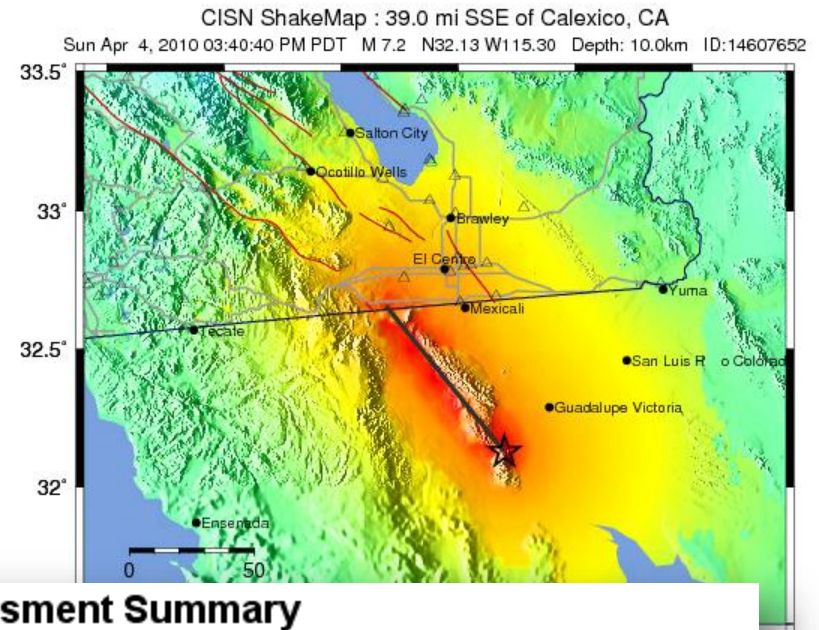
Bridge Assessment Details

Bridges presented in the table below are sorted in order of severity of impact (exceedance ratio). The list includes

Bridge Name	Bridge Number	Dist-C
53 2078 - VALLEY BLVD UC	53 2078	07-LA
53 2078K - VALLEY BLVD UC	53 2078K	07-LA
53 1158 - GRIER STREET POC	53 1158	07-LA
53 2107 - TEMPLE AVENUE OC	53 2107	07-LA

7.2 Calexico April 2010

ShakeCast identified the only bridge damaged in this event as the top priority for inspection.



Bridge Assessment Summary

Maximum Peak 1.0 sec Spectral Acceleration: 48.5782%g

Maximum Acceleration: (not measured)

Total number of bridges assessed: 219

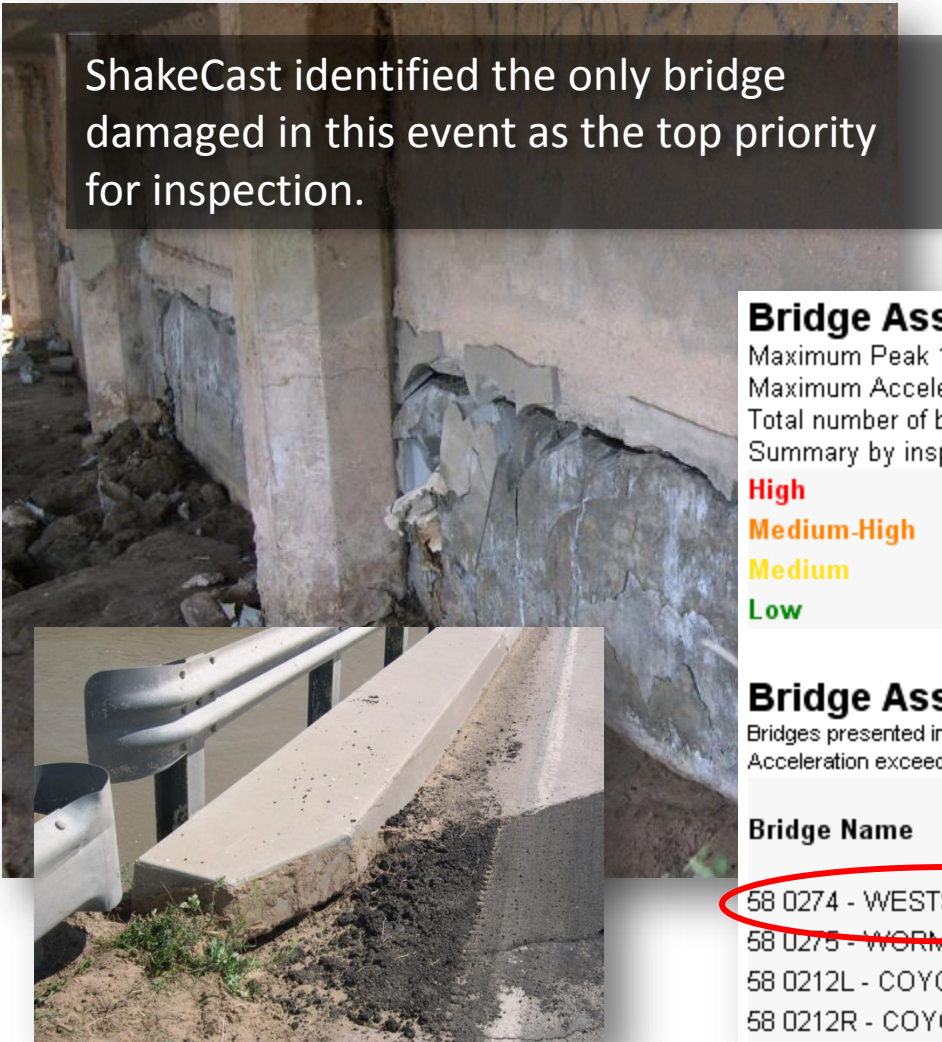
Summary by inspection priority:

High	[NULL]	High Priority for full engineering assessment
Medium-High	[NULL]	Medium-High Priority for full engineering asses
Medium	[NULL]	Medium Priority for full engineering assessment
Low	219	Low Priority for full engineering assessment; qu

Bridge Assessment Details

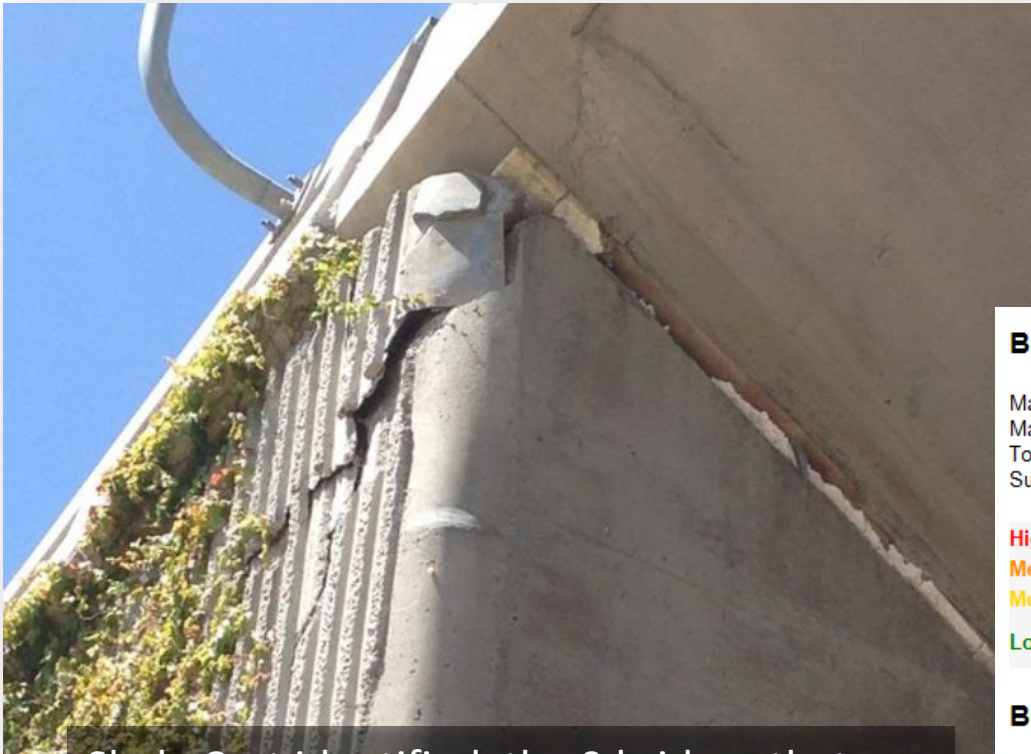
Bridges presented in the table below are sorted in order of severity of impact (exceedance ratio). The list Acceleration exceeds 10% g.

Bridge Name	Bridge Number	Dist-Cty-Rte-PM
58 0274 - WESTSIDE MAIN CANAL	58 0274	11-IMP-098-22.02
58 0275 - WORMWOOD CANAL	58 0275	11-IMP-098-22.07
58 0212L - COYOTE WELLS OH	58 0212L	11-IMP-008-R13.97
58 0212R - COYOTE WELLS OH	58 0212R	11-IMP-008-R13.93



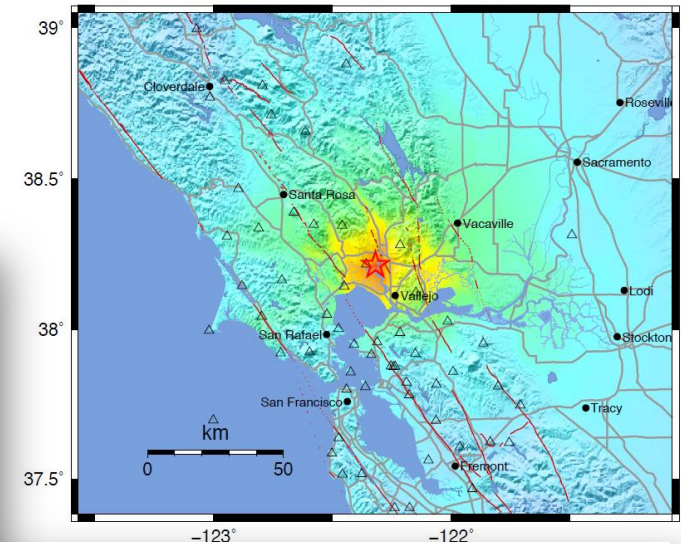
6.0 Napa

August 2014



ShakeCast identified the 9 bridges that sustained minor damage. They were in the top 40% of a list of 87 total. Over 2700 state bridges were in the ShakeMap region.

CISN ShakeMap : 6.7 km (4.2 mi) NW of American Canyon, CA
 Aug 24, 2014 10:20:44 AM UTC M 5.7 N38.21 W122.32 Depth: 10.8km ID:72282711



Bridge Assessment Summary

Maximum Peak 1.0 sec Spectral Acceleration: **30.76%g**

Maximum Acceleration: **(not measured)**

Total number of bridges assessed: **87**

Summary by inspection priority:

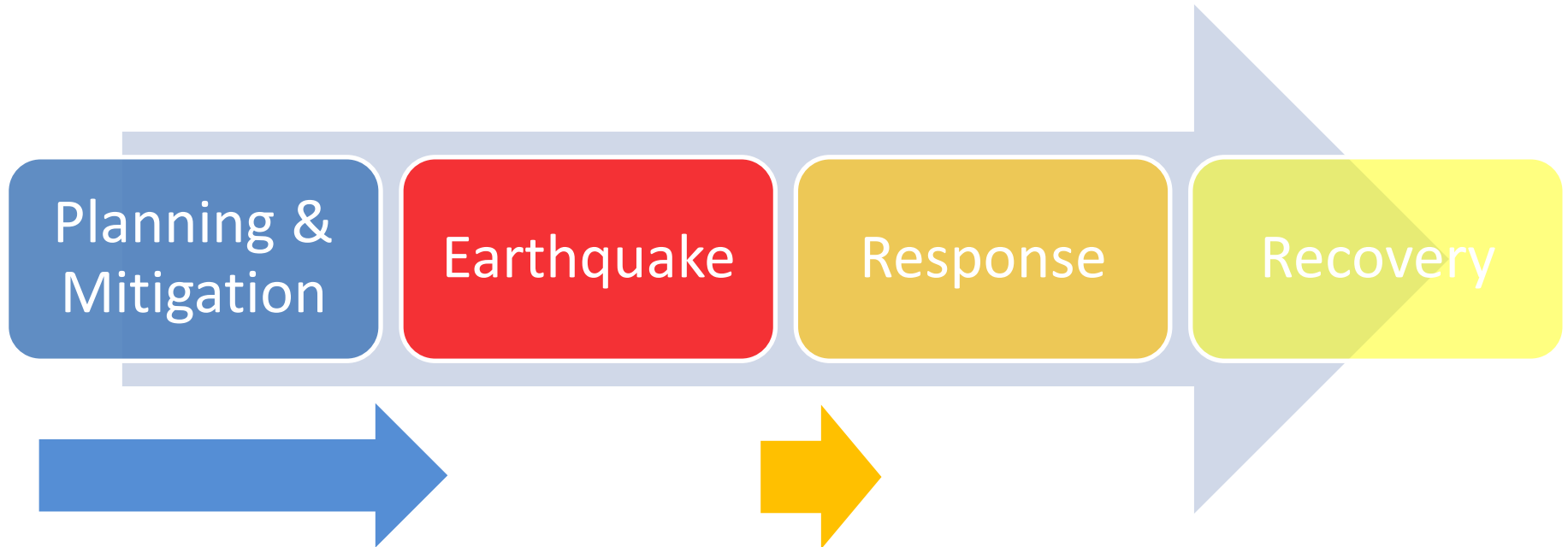
High	(none)	High Priority for full engineering assessment
Medium-High	(none)	Medium-High Priority for full engineering asses
Medium	(none)	Medium Priority for full engineering assessment
Low	87	Low Priority for full engineering assessment; q sufficient.

Bridge Assessment Details

Bridges presented in the table below are sorted in order of severity of impact includes all state bridges in the area of shaking where the 1sec Peak Spectra

Bridge Name	Bridge Number	Dist-Cty-Rte-PM	Inspection Priority
21 0049 - NAPA RIVER BOH	21 0049	04-NAP-029-R6.99	Low
21 0098 - STANLEY GREEN	21 0098	04-NAP-029-R8.33	Low

ShakeCast for Planning & Mitigation



ShakeCast can also be used to evaluate the current bridge inventory against scenario earthquakes and significant historical events.

(Over 280 California scenarios available.)

ShakeCast raises situational awareness in the hours immediately following the event.

Golden Guardian, November 2008

